

THE APRIL 1986 ICE JAM

AT SIMONDS, N.B.

NEW BRUNSWICK SUBCOMMITTEE ON RIVER ICE

Department of Municipal Affairs and Environment
Water Resources Planning Branch

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PREFACE

The first edition of this report was completed in November, 1986. The water level data utilized were based on preliminary hourly readings.

In February, 1987, the "quality controlled" water level data for the Simonds and Hartland gauges were made available by the Water Survey of Canada. Slight differences between the hourly data, utilized in the first edition, and the "quality controlled" data were found. Therefore, this second edition was prepared to rectify these differences.

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CHAPTER 1

INTRODUCTION

The objective of this report is to document the sequence of meteorologic and hydrologic events which led to the ice jam flooding in the Simonds area in early April 1986. The report will also discuss the major factors contributing to the ice jam formation and subsequent flooding, as well as presenting a brief description of the reported damages in the Simonds area.

Spring ice breakup on the Saint John River between Beechwood and Woodstock normally starts in the upstream reaches and moves downstream as the River's discharge increases and the ice cover weakens. Every year the breakup of the river's ice cover in this reach results in the accumulation and lodgement of fragmented ice cover at various locations. The duration and severity of such ice lodgments are dependent upon the prevailing hydraulic conditions at the river section where the ice floes stopped and jammed.

The geometry of the river reach between Stickney and Hartland is characterized by a number of islands, gravel bars and narrow sections, Figure 1, which make this reach a prime location for ice jam lodgment. River observations over the years show frequent ice lodgment at Stickney, Peel Island and Upper Becaguimec Island. Normally the duration of such lodgment is brief and does not cause severe flood damages to adjacent areas. In April 1986

however, hydraulic, climatic and ice conditions in the Simonds Hartland area resulted in the formation of a severe ice jam at the upstream end of Upper Becaguimec Island. High water behind the jam flooded the road on the west side of the Saint John River (Route 103) leading to the village of Simonds. There was also some flooding along Highway 105 on the east side of the River. This high water forced the evacuation of several families from their homes. Newspapers reported flood damages to several homes, businesses and a private air field in the Simonds area. Damages to a number of utility poles along the river banks were also reported.

CHAPTER 2

CHRONOLOGY OF EVENTS

This chapter presents the meteorologic, hydrologic, and hydraulic events which lead to the formation of the ice jam near the Village of Simonds in April 1986.

2.1. METEOROLOGICAL EVENTS

The most important meteorological factors affecting ice formation and breakup in the Saint John River are temperature, precipitation, heat gain, and solar radiation. Due to the limited information available, only the impacts of temperature and precipitation on the River's ice conditions during the 1985-86 winter season are presented and discussed.

Generally the 1985-86 winter season was characterized as colder than normal and with below average snowfall. The depth of snow over an ice cover has a direct influence on the growth rate of the ice cover, as well as on its quality and strength.

During the month of December 1985 average temperature over the river reach between Beechwood and Woodstock was -10.5°C , which is 3.5°C below normal. The total snowfall for the month was only 50% of the long term average. This below average snowfall resulted in a rapid growth of a strong ice cover over the river reach under consideration. This is due to the reduction of the "insulation" effect normally provided by the snow cover.

Temperature during the first two weeks of January 1986 was near its seasonable value. This sequence was followed by two weeks of generally sunny and relatively warm weather. A period of heavy rain was also experienced toward the end of the month. Records from the Fredericton Airport show that maximum day-time temperatures were above freezing for the period of January 17 to January 28 inclusive, with the exception of January 24. A temperature as high as $+14^{\circ}\text{C}$ was recorded on January 27. The records also show that a total of 45 mm (1.8 ins) of rain were collected at the Fredericton Airport; out of these 22 mm (0.9 ins) of rain were recorded on January 27 alone. Similar trends of air temperatures and precipitation were noted from the records at the Houlton and Beechwood Climatological stations. A listing of available meteorological data is presented in Appendix A.

Average temperature during February was -10°C , which is about one degree below the seasonable value. However, the total snowfall recorded for the month was 30 cm (12 ins), which is about 40% of normal.

Transition from a winter to spring weather pattern was gradual with air temperatures during the month of March being only one degree below the seasonable value. Maximum day-time air temperatures during the last week of the month were well above freezing. Temperatures of 18.6, 18.9, 17.0°C were recorded at Fredericton, Houlton, and Beechwood climatological stations respectively. Precipitation

over the basin varied considerably; while it was 150% of normal at Fredericton, the Beechwood climatological station record shows only 80% of normal.

The first week of April continued to be warm and sunny with day-time temperatures fluctuating slightly around the +15°C mark over the entire Saint John River basin.

2.2 ICE JAM EVENTS

In order to analyze the events that took place during the April 1986 ice jam near Simonds, it is essential to review earlier ice jam events which occurred in the last week of January of the same year. Such events have a direct impact on the hydraulic conditions of the river reach between Beechwood and Hartland. These hydraulic conditions constitute major factors leading to the formation of the April ice jam near Simonds.

2.2.1 January 1986 Ice Jams

Warm temperature over the basin during the last two weeks of January resulted in a considerable melting of the snow cover, and the subsequent increase in the runoff into the river. Average daily discharge at Florenceville increased from 9,200 cubic feet per second (cfs) (260 cubic meters per second (cms)) on January 26 to 32,600 cfs (923 cms) on January 28. The increased river flow coupled with above normal temperatures and the warm rain on January 27, resulted in the break up of the ice cover in the upper reach near Beechwood dam.

On the evening of January 28 the river was open from Florenceville to about 2 km (1.3 mi) above the Hugh John Flemming bridge at Hartland. Examination of the Simonds' water level gauge records indicates that the fragmented ice cover was lodged at Upper Becaguimec Island downstream of the gauge forming a minor ice jam. This is evident from the increase in the water level at the gauge from 148.4 ft (45.22 m) at 0300 hr to 157.5 ft (48.00 m) at 0900 hr on January 28. The water level at the gauge reached its maximum of 158.5 ft (48.30 m) at 1700 hr. One hour later the water level at the Simonds' gauge dropped 4.6 ft (1.38 m) to elevation 153.9 ft (46.92 m), signaling the release of the ice jam from its first lodgment position downstream of Simonds.

As the River discharge continued to increase, it resulted in the fragmentation of the ice cover between the Hugh John Flemming bridge and Sproule's Island about 2 km (1.3 mi) downstream of the town of Hartland. When the ice jam released from Upper Becaguimec Island, it continued its travel downstream accumulating more ice before being stopped at Sproule's Island. This caused the water level at Hartland gauge to increase from 143.8 ft (43.83 m) to 152.6 ft (46.52 m) between the 1700 and 1900 hrs on January 28. The water level continued to increase at Hartland and reached its maximum level of 153.9 ft (46.91 m) at 21:40 on January 28.

In the following days seasonable cold winter temperatures returned to the basin, with a consequent gradual reduction in river discharges. The fragmented ice cover remained lodged on Sproule's Island. While lodged in this position throughout the rest of the winter, below normal temperatures resulted in considerable consolidation and the freezing of the fragmented ice floes together to a great depth. From ice observation on April 4, it is estimated that the January jam had been frozen to a depth of 10 to 12 feet (3 to 3.6 m) approximately (see Appendix B). That is, the ensuing climatic conditions resulted in appreciable strengthening of the lodged ice accumulation at Sproule's Island; while the remainder of the river reach between Beechwood and Woodstock returned to normal winter ice conditions.

2.2.2 April 1986 Ice Jams

In mid to late March, the climatic transition from winter to spring temperatures began. Day-time temperatures were consistently above freezing, while minimum night-time temperatures were fluctuating between $+5.7^{\circ}\text{C}$ to -3.4°C . This resulted in a gradual increase in river flows and the start of the ice cover deterioration and breakup in the upper reach of the river between Beechwood and Hartland. The breakup process was accelerated by a moderate amount of rainfall over the basin and above normal day-time warm temperatures (up to $+19^{\circ}\text{C}$). The combination of high temperatures

and moderate rainfall resulted in the increase of the average daily flows at Beechwood from 28,000 cfs (793 cms) on April 1 to 112,000 cfs (3,172 cms) on April 4.

River reconnaissance on April 1 indicated that the ice cover in the Hartland area appeared to be quite solid. However, open water channels were observed on both sides of Peel Island (Lower Presque Isle), a sign of deterioration of the ice cover in this area. Discharges from Beechwood were steady most of the day at 25,500 cfs (722 m) increasing gradually over night due to the rapid increase of the inflow into the headpond, which resulted in a 5 ft (1.5 m) increase in the headpond water level at the dam. Water level at the Simonds gauge, Figure 2, was steady during the night fluctuating slightly around the 151.9 ft (46.30 m) mark.

As the inflow into the Beechwood head pond continued to increase, discharges were increased from 42,300 cfs (1,198 cms) at 0800 hr to 77,000 cfs (2,181 cms) at 2400 hr on April 2. Water level in the Beechwood head pond rose slightly over the same period indicating that discharges from the head pond were less than the inflow into it.

During the early morning hours of April 2 broken ice above Stickney moved downstream and lodged on Peel Island. The ice moved again during the noon hour with the head of the jam resting on the gravel bar at the upstream end of Upper Becaguimec Island

and the tail of it at the lower end of Peel Island. The ice jam remained in this position overnight except for a few consolidation movements. As a result of the increase in river flows and the significant reduction in the discharge capability of the river due to the ice jam, water started to back up behind the jam resulting in over night flooding of Route 103 near Simonds.

Water level at the Simonds gauge showed a sudden increase of 4.7 ft (1.43 m) at 1300 hr on April 2 to reach an elevation of 159.2 ft (48.52 m). This increase was due to the release of Peel Island's ice jam and its stored water. When the Peel Island's ice jam was moved and stopped again at Upper Becaguimec Island water level increased gradually at the Simonds gauge to 163.5 ft (49.83 m) at 2100 hr. The jam was stable overnight with the water level at Simonds fluctuating slightly around 163.0 ft (49.7 m) until 1300 hr on April 3, (see Figure 2).

On April 3, runoff from the upper basin continued to increase resulting in the increase of the inflow into Beechwood headpond. Moreover, ice jam movements in the upper reach of Beechwood head pond caused a significant fluctuation to the inflow at the Beechwood dam. For example, at 1400 hr inflow into the headpond was calculated at 95,000 cfs (2,690 cms), and by 1500 hr it reached 162,000 cfs (4,588 cms) to drop two hours later to 54,000 cfs (1,529 cms) gradually increasing to 105000 cfs (2,974 cms) at 1900 hr, then suddenly jumped to 202,000 cfs (5,721 cms) at 2000 hr. However,

discharges from Beechwood dam were gradual; where the discharges from the dam were steadily increasing from 97,000 cfs (2,747 cms) to 112,000 cfs (3,172 cms) between the 1400 hr and 2000 hr.

As the river flow continued to increase during the day, water level behind the jam continued to rise reaching its maximum level of 167.8 ft (51.14 m) at the Simonds gauge at 18:22 hr on April 3. High water levels caused the flooding of the highway to Simonds isolating the Village for a number of hours, as well as forcing the evacuation of a number of families from their homes. Route 105 near Upper Brighton was also flooded, and a few residents in the area reported water damages to their basements. Ice also damaged a number of utility poles; however interruptions to electrical and telephone services were minor. Appendix B presents several photographs of flooding and ice conditions in the river reach between Peel island and Hartland.

Between 2100 and 2200 hrs on April 3 the jam at Upper Becaguimec Island finally broke resulting in a drop of the water level at Simonds by 7.5 ft (2.29 m) in less than an hour. The water level continued to recede and at 0100 hr on April 4 the water level had dropped a total of 16.0 ft (4.88 m) to an elevation 152.8 ft (46.58 m) at Simonds.

In addition to the ice jams lodged on Peel Island and Upper Becaguimec Island, the winter ice jam lodged on Sproule's Island downstream of the town of Hartland was having its effect on the water levels in the area. Since the winter jam at Sproules' Island had not dislodged from its position and had consolidated and refrozen in place, it caused a significant reduction in the discharge capacity of the river channel below Hartland. This reduction in the discharge capability of the river's channel caused high water levels over a long reach of the river upstream of Sproule's Island.

On April 1, water level at Hartland gauge was 149.3 ft (45.50 m) most of the day. By 1500 hr the water level at Hartland started to increase slowly to reach 151.8 ft (46.28 m) at 1500 hr on April 2. During the evening of April 2 the water level at Hartland continued its increase but at a faster rate to reach an elevation of 155.4 ft (47.35 m) by midnight. Such an increase in the water level at the Hartland gauge is attributed to the release of the ice jam from Peel Island, where the water released from the jam could not pass the partially blocked river section at Sproule's Island. Water levels at Hartland gauge fluctuated slightly at the 155.8 ft (47.50 m) mark until the afternoon of April 3, (see Figure 3).

On April 3 at 1400 hr, Hartland gauge showed a temporary drop of one foot (0.3 m) which is attributed to minor consolidation movements in the Sproule's Island jam. Water level at Hartland

gauge reached its maximum elevation of 157.5 ft (48.01 m) at 21:53 hr, less than one hour after the upstream jam at Upper Becaguimec Island was dislodged. At 2300 hr, water level at the Hartland gauge dropped by 4.1 ft (1.25 m) to elevation 153.4 ft (46.76 m) indicating the release of the ice jam at Sproule's Island. Water level at Hartland continued to recede to reach an elevation of 150.6 ft (45.90 m) by the morning of April 4.

CHAPTER 3

ANALYSIS OF SIMONDS' ICE JAM FLOOD

This chapter presents an analysis of the factors which led to the formation of the ice jam at Upper Becaguimec Island and consequent flood damages in the Simonds area.

The likelihood of accumulation and lodgment of a fragmented ice cover and consequent ice jam formation increases when a combination of meteorologic, hydrologic and hydraulic conditions over the basin coincide to provide the prerequisite conditions for an ice jam to form. The geometry of the river's section at which an ice jam is likely to form should satisfy certain hydraulic conditions required for the initiation of such ice jam.

A period of warm weather prevailed over the basin during the last two weeks of March. At the Fredericton Airport, the maximum day-time temperatures fluctuated between $+18.6^{\circ}\text{C}$ and $+9.5^{\circ}\text{C}$ for the period of March 26 through April 3, inclusive, while the minimum night temperatures for the same period were moderate and ranged between -3.4°C and $+2.2^{\circ}\text{C}$. Records also show that a total of 43 mm (1.7 in) of rain fell at Fredericton on March 27. Climatological information for Beechwood and Houlton climatological stations are not complete for this period. However data available showed strong indications that the same trend of weather conditions prevailed over the Saint John River basin. The New Brunswick

Electric Power Commission reported clear and sunny conditions throughout the basin starting March 28 until the release of the ice jams from the Simonds-Hartland area during the night of April 3.

A prolonged period of above freezing temperatures and bright sunshine over the basin resulted in a large heat gain by the river's ice cover, and the resultant weakening of its strength. Moreover, the moderate rain on March 27 and warm temperature caused a high rate of snow melt, gradually increasing the discharge in the river and consequently increasing the pressure on the ice cover. This eventually led to the breakup of the weak ice cover in the upper river reach between Beechwood and Hartland. As the fragmented ice cover traveled downstream it accumulated and lodged at a number of locations along river reach. The river sections at these locations are characterized as being restrictive; and historically known as potential ice jam sites.

On April 2, the movement of the fragmented ice cover was halted at the narrow section of the river downstream of Stickney, (see Figure 1). Shortly after the jam was lodged at this position it was released under the pressure of increasing river flow and the weakening of the ice strength downstream of the jam. When the jam was released from the Stickney position it was stopped at Peel Island. Although the jam was lodged at Peel Island, upstream of Simonds water gauge, water level at the gauge showed a significant

increase between 2300 hr on April 1 and 1000 hr on April 2. Such an increase in the water level is attributed to the reduction in the discharge capacity of the river section at Sproule's Island where the winter ice jam had been lodged since January. With reduced discharge capacity at Sproule's Island water was backed up behind the Sproule's Island ice jam and extended to the Simonds area resulting in the increase in the water level recorded at the Simonds gauging station.

A few hours after the jam stopped at Peel Island it was dislodged from this position under the pressure of increasing river flows. It stopped again at the upstream end of Upper Becaguimec Island. The jam remained lodged in this position from noon on April 2 until shortly after 2100 hr on April 3. The duration of the jam lodgment on Upper Becaguimec Island during the spring 1986 ice run was considerably longer than normal. This is attributed to the fact that the backwater effect from the Sproule's Island ice jam extended to a point upstream of the lodgment point on Upper Becaguimec Island. Consequently, this reduced the force exerted by the river's flow on the jam to such an extent so as not to dislodge it from its position at the Upper Becaguimec Island. Therefore, higher than "normal" breakup river flow was required to release the jam from Upper Becaguimec Island. Only when the river flow reached about 122,000 cfs (3,455 cms), was the force exerted by the flow sufficient to dislodge the jam from Upper Becaguimec Island.

During late March and early April of 1976 a combination of severe hydrologic and climatologic conditions resulted in a series of ice jams along the river reach between Beechwood and Woodstock. It is estimated that the return period of severe ice jams, similar to those experienced during 1976, is greater than a 100 year. It is noteworthy that the dislodgment discharge of the 1976 ice jam near Upper Becaguimec Island was relatively high. However, the river flow required to dislodge an ice jam from the same location during the April 1986 ice jam events was about twice that experienced in the 1976 event.

It is important to discuss briefly the effects of the discharges from the Tinker dam on the Aroostook river on the water level at Simonds. During the afternoon of April 3 the inflow into Tinker's head pond increased considerably. In order to maintain the water level at the dam at an acceptable level, the discharge from Tinker dam was increased from 15000 cfs (425 cms) to 43000 cfs (1,218 cms) in less than one hour. This sudden increase in river flow was partially contained within the Beechwood head pond until the water level at the dam reached its maximum operating level of 243 ft (74.06 m). At this point it became necessary to discharge all the inflow reaching the dam in order to maintain the water level at the dam within the allowable limit. This extra discharge resulted in a 2 ft (0.61 m) increase in the water level at Simonds.

As the river's flow increased sufficiently to dislodge the jam from Upper Becaguimec Island on the night of April 3, the water stored behind the jam was suddenly released resulting in a short period of very high discharge in the Hartland area. This was sufficient to dislodge the strengthened ice jam which had been lodged on Sproule's island since January. This is evident from the observed one hour time lag between the sudden water level drop at the Simonds gauge and the Hartland gauge.

CHAPTER 4

SIMONDS ICE DAMAGES

The ice jam flooding in early April 1986 between Hartland and Stickney caused both inconvenience and damages to a number of Simonds residents, as well as some residents in neighboring communities. Several families from the Simonds area were evacuated from their homes by boats and a helicopter. Some evacuees moved in with friends or relatives, while others were taken to a motel above Woodstock. One mobile home was displaced sideways off its foundation by the ice.

In addition, a private airstrip was completely flooded, see Appendix B. There were three light aircraft submerged under water and about 1200 feet (365.74 m) of the air strip was severely damaged. The paved parking lot was completely washed away.

Route 103, on the west side of the river, was flooded with water and ice and it had to be closed to traffic between April 3 and April 5. There were some damages to the shoulders and guardrails. Route 105, on the east bank, was also closed to traffic during the night of April 3 due to water and ice flooding. Ice damages to a number of utility poles occurred along the river banks with minor interruption to telephone and power services.

According to the N. B. Emergency Measures Organization's (EMO) preliminary report, thirty seven private homes suffered water and ice damage. A substantial amount of heating oil was lost and there was concern that it might leach into the ground and reach the water table at sometime in the future. Results of water tests taken by the Department of Health indicated that two wells were contaminated with coliform and fecal bacteria.

A truck salvage and repair business was flooded, resulting in damage to two buildings and their contents, including a rebuilt transmission, power tools and building insulation. Damage to a farm in the Simonds area included commercial packing bags and boxes inside the potato warehouse. Two grain bins containing 5800 bushels of oats and 3000 bushels of wheat were flooded.

Beside these damages there were other costs due to the ice jam floods in the Simonds area. These include the costs for the evacuation and relocation of a number of families, cleanup of private and public properties, loss of wages and loss of business.

CHAPTER 5

CONCLUSIONS

River geometry of the Saint John River between Stickney and Hartland is characterized by a series of islands, gravel bars, and restrictive narrow sections. River reaches with such characteristics are potential locations for ice jam formation. Historically, frequent ice jam lodgments and flooding have been observed at Stickney, Peel Island, and Upper Becaguimec Island.

Water and ice damage in the Simonds area during April 1986 ice jam events were more severe than normal due to the long duration of ice lodgment on Upper Becaguimec island and the subsequent ice jam formation. The ice jam remained in this position longer than normal because of the reduction in the dislodgment force exerted by the river flow. This reduction was the result of high water level in Simonds area, which was created by the back water behind the consolidated and strengthened winter jam lodged on Sproule's Island. The ice jam was dislodged from Upper Becaguimec Island when the river flow was about 122000 cfs(3,455 cms) , which is approximately twice the river flow required to dislodge an ice jam from this location in 1976.

The combination of backwater effect from the Sproule's Island ice jam, longer than normal ice lodgment on Upper Becaguimec Island, and very high dislodgment river flow required to move the ice jam from Upper Becaguimec Island resulted in an extremely

high water level in Simonds area in early April 1986. Such high water level resulted in water and ice damages to several private and public properties in the area.

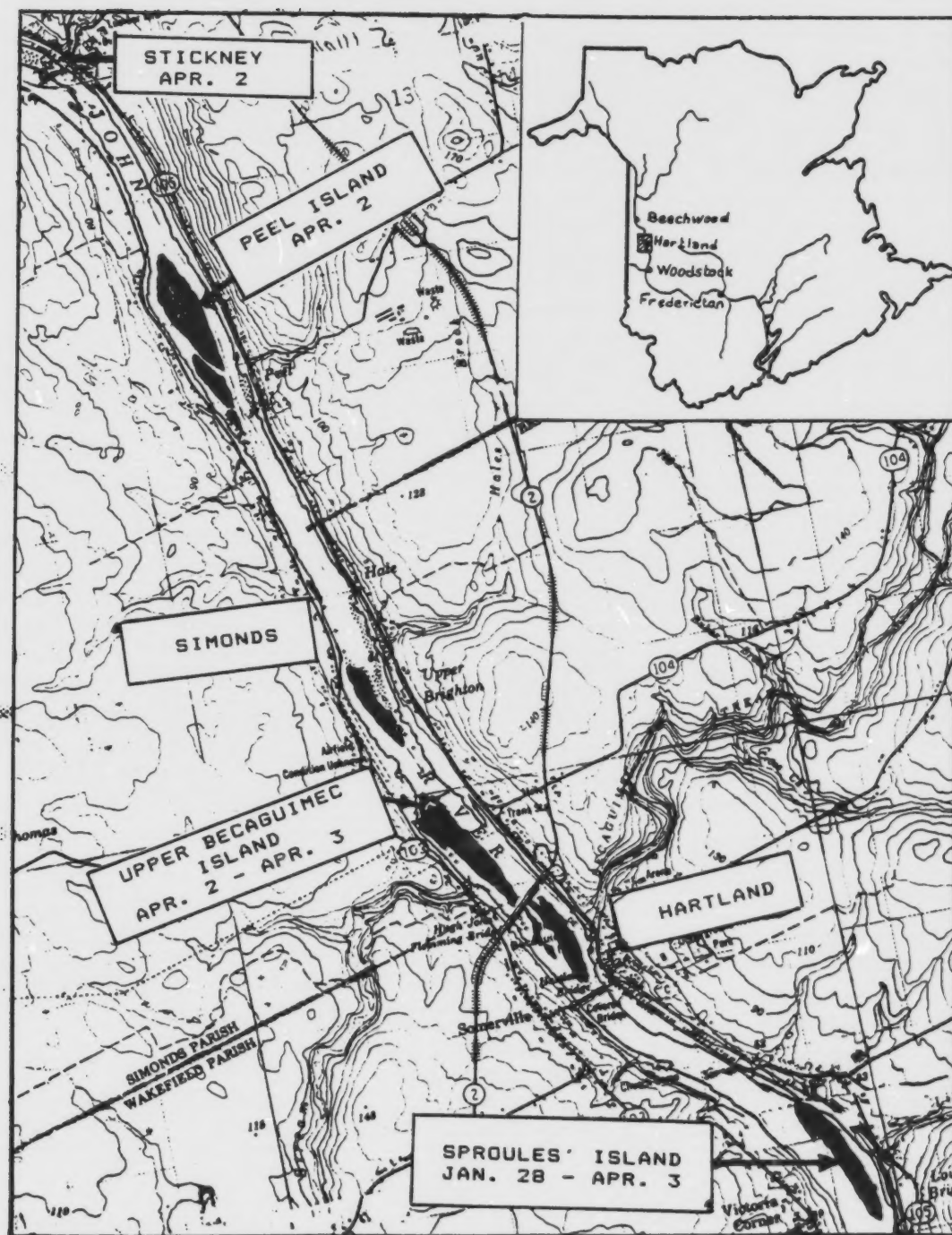


FIG. 1: APRIL 1986 ICE JAM LOCATIONS

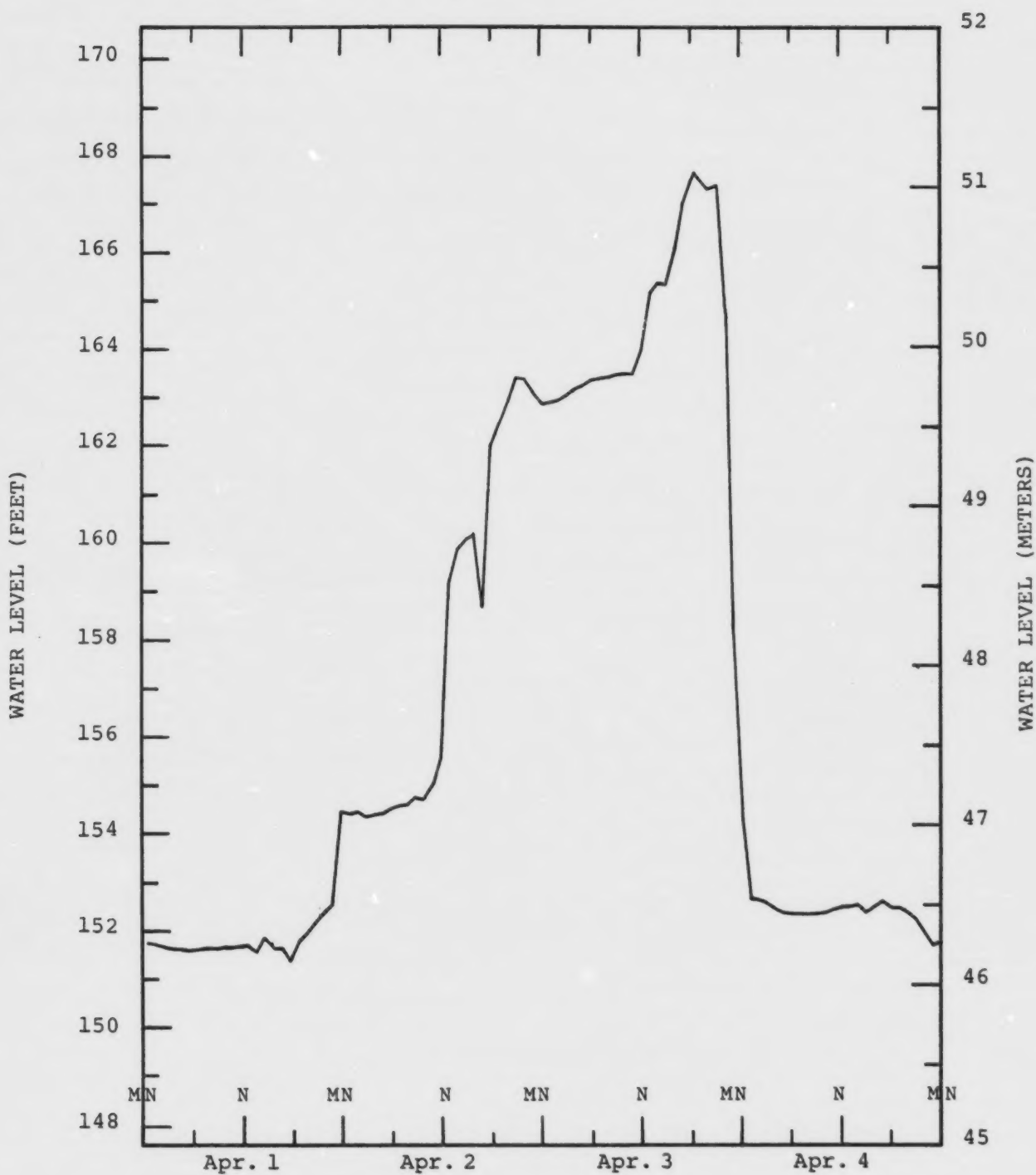


FIG 2: WATER LEVELS AT SIMONDS
APRIL, 1986

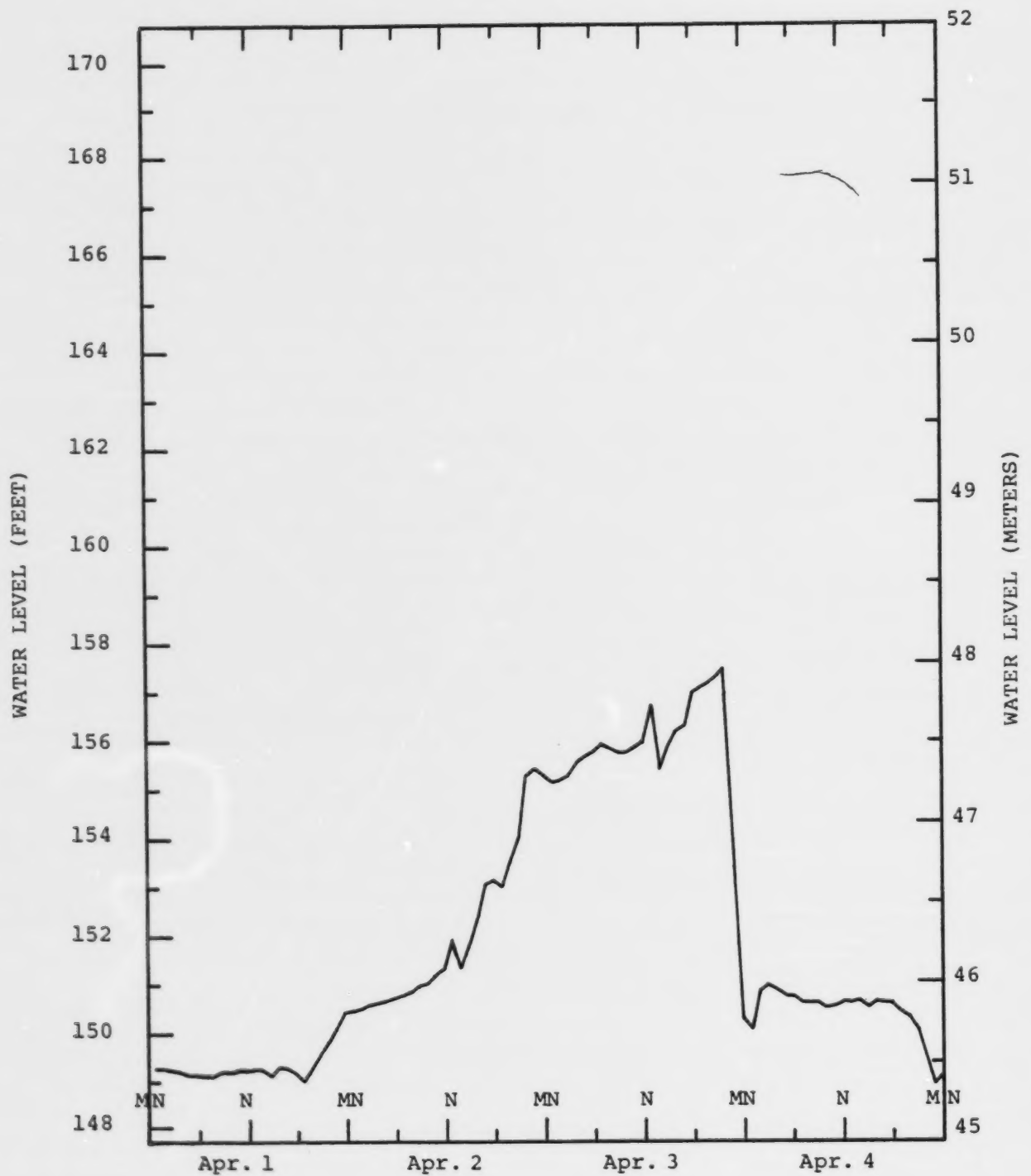


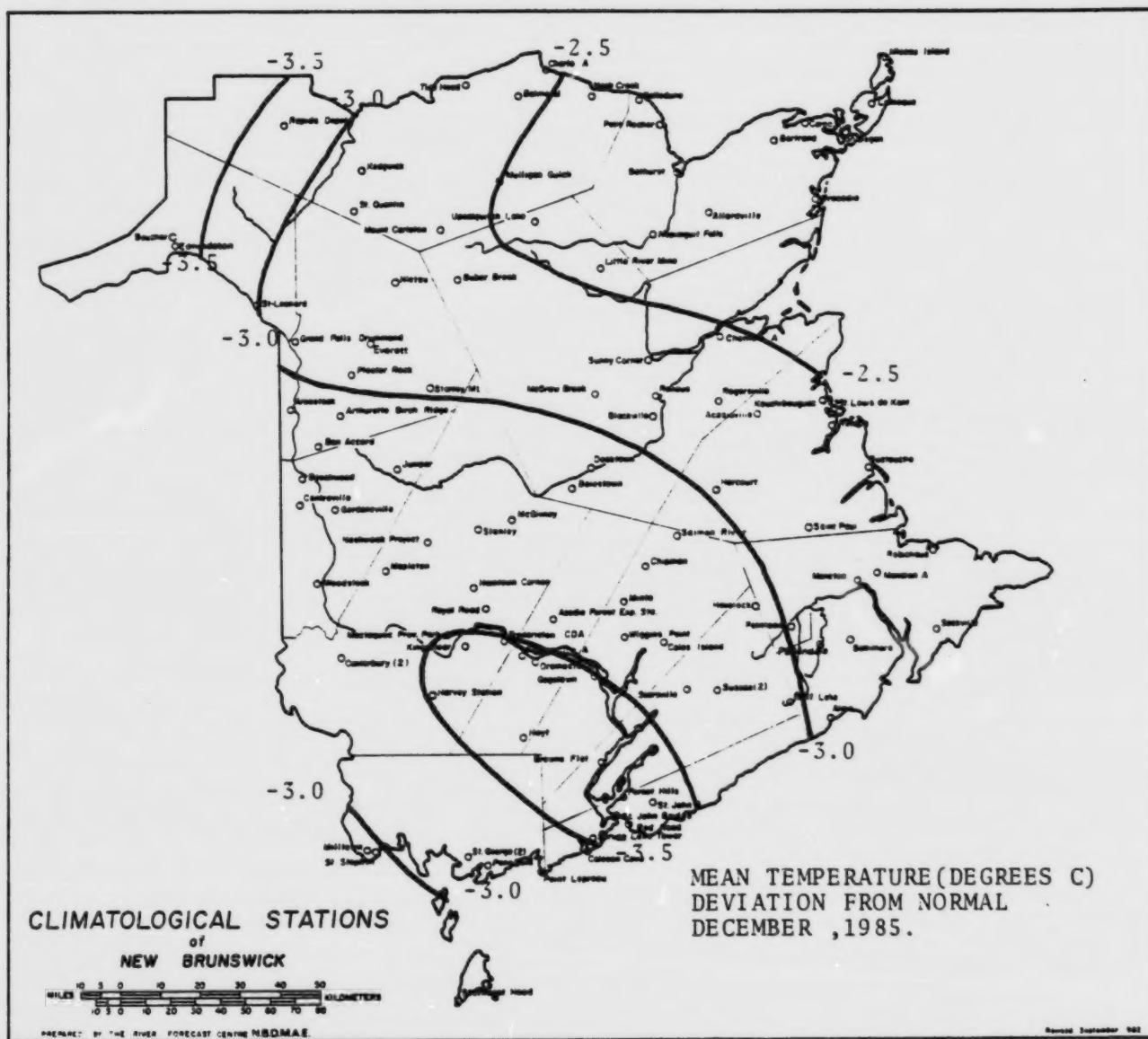
FIG 3: WATER LEVELS AT HARTLAND
APRIL, 1986

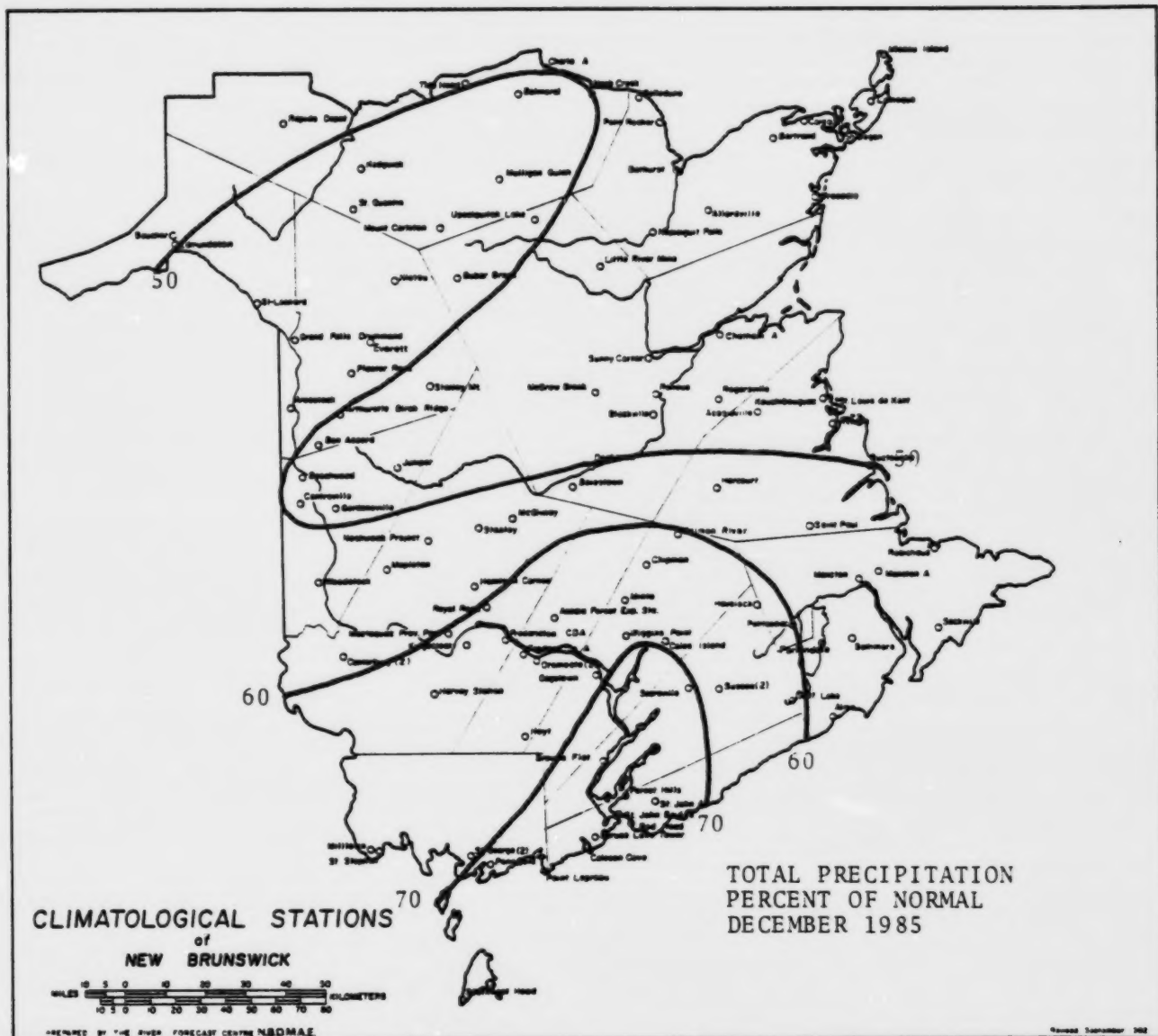
APPENDIX A

METEOROLOGICAL DATA

METEOROLOGICAL DATA
DECEMBER 1985

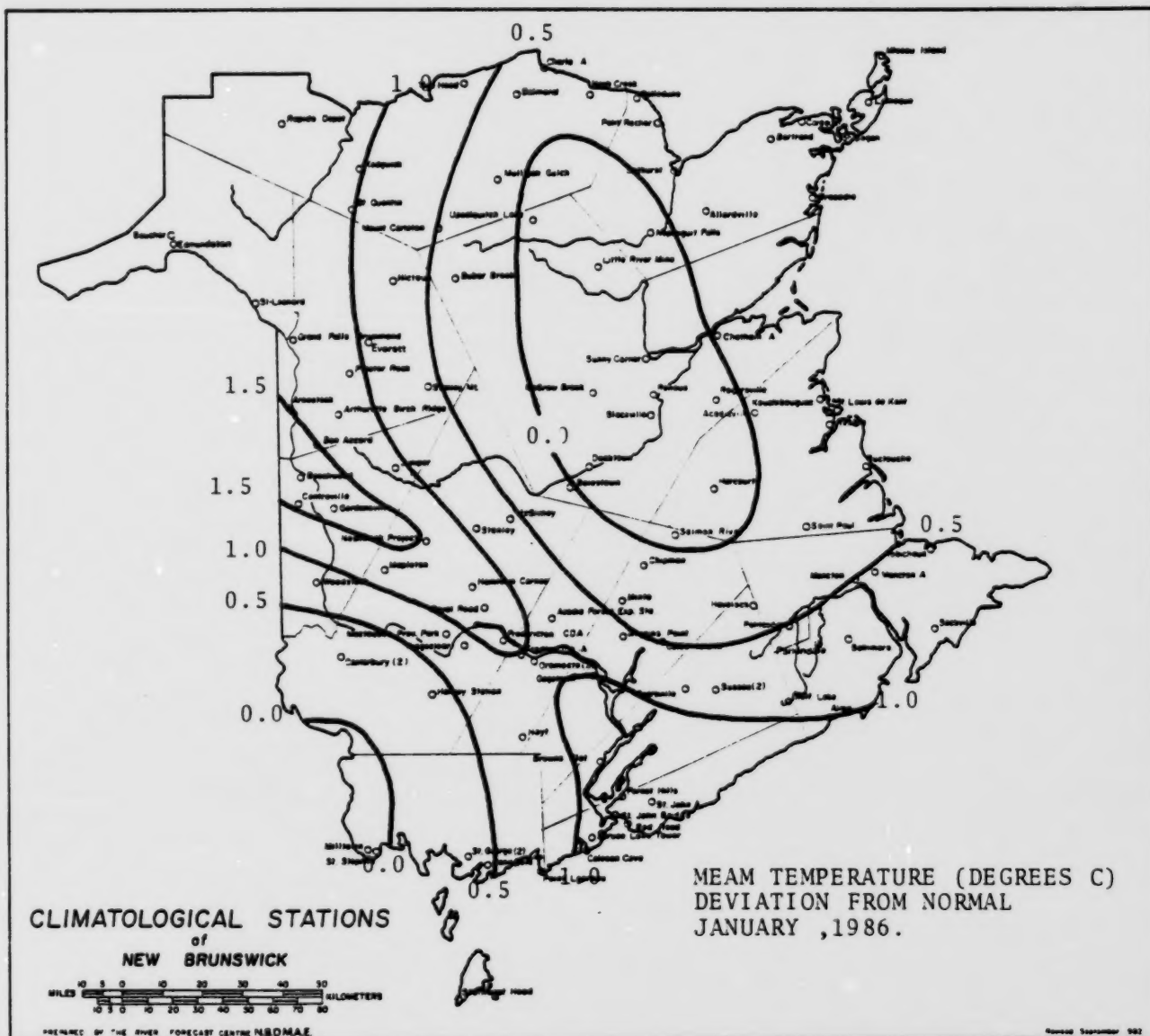
DAY	FREDERICTON			BEECHWOOD			HOULTON		
	TEMP. (°C)		PRECIP. (mm)	TEMP. (°C)		PRECIP. (mm)	TEMP. (°C)		PRECIP. (mm)
	MAX.	MIN.		MAX.	MIN.		MAX.	MIN.	
1	-0.60	-14.30	1.80	4.50		2.20		-16.70	2.30
2	13.40	-3.80	14.80		-10.00			-0.60	10.90
3	-1.10	-7.10	0.00	-5.00		0.00		-8.90	
4	-4.40	-10.00	0.00	-5.00	-12.00	0.00			0.00
5	-2.90	-12.00	0.00	-3.00	-15.50	0.00	-3.30	-15.60	0.00
6	-1.90	-15.00	0.00		-16.00			-15.60	0.00
7	-3.60	-14.20	0.00				-2.80	-17.20	0.00
8	-0.20	-9.60	0.00	-1.50		0.00	-0.60	-17.20	0.00
9	-0.60	-8.60	0.00	-1.00	-10.00	0.00	-1.10	-11.10	0.00
10	-0.70	-7.60	0.00	0.00	-10.00	0.00	0.00	-10.00	0.00
11	1.50	-7.20	T	-0.50	-11.00	T		-9.40	1.00
12	-4.00	-9.10	2.80	-4.00	-8.50	0.00	-4.40	-5.60	1.50
13	-4.10	-18.40	15.90		-16.50			-17.80	7.10
14	-2.50	-5.40	1.50				-2.80	-5.00	0.30
15	-11.80	-17.40	0.00	-14.00		21.00	-12.80	-20.60	0.00
16	-2.90	-21.80	5.90	-5.00	-20.00	2.00	-5.00	-16.10	0.80
17	-7.30	-12.30	6.00	-9.50	-20.00	T	-7.20	-16.10	0.50
18	-7.70	-20.20	3.60	-7.00	-21.00	0.00	-6.70	-19.40	T
19	-15.20	-21.50	0.00	-16.00	-23.50	0.00	-17.20	-24.40	0.00
20	-12.70	-27.10	0.00		-30.00			-28.90	0.00
21	-11.40	-21.80	0.00					-23.30	0.00
22	-9.40	-26.30	1.60	-15.00		3.00	-10.60	-26.10	2.00
23	0.00	-20.00	8.00	-5.00	-22.00	6.00	-5.00	-21.70	2.80
24	0.40	-17.00	T		-14.00			-13.90	0.00
25	7.20	-1.30	7.10					0.60	0.30
26	-6.30	-15.40	0.00	-15.00		11.00	-15.60	-18.90	0.00
27	-6.40	-24.60	6.60		-24.50		-5.60	-26.70	1.30
28	-2.80	-10.70	0.00				-4.40	-12.20	0.00
29	-4.60	-24.60	0.00	-6.00		0.00	-6.10	-20.00	0.00
30	-5.00	-20.30	0.00	-7.00	-19.00	T		-19.40	0.00
31	5.10	-21.20	0.80		-21.00		2.80	-18.90	T

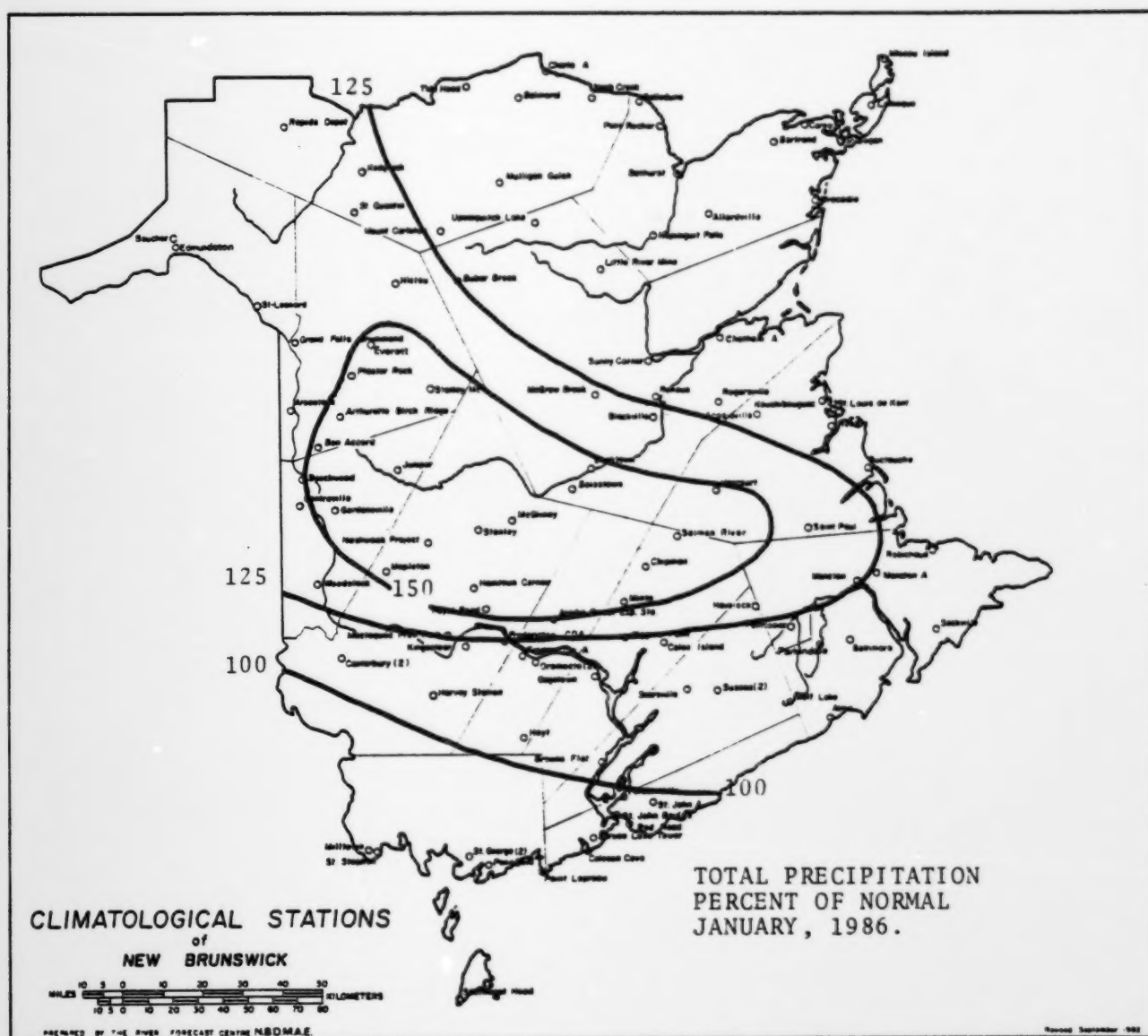




METEOROLOGICAL DATA
JANUARY 1986

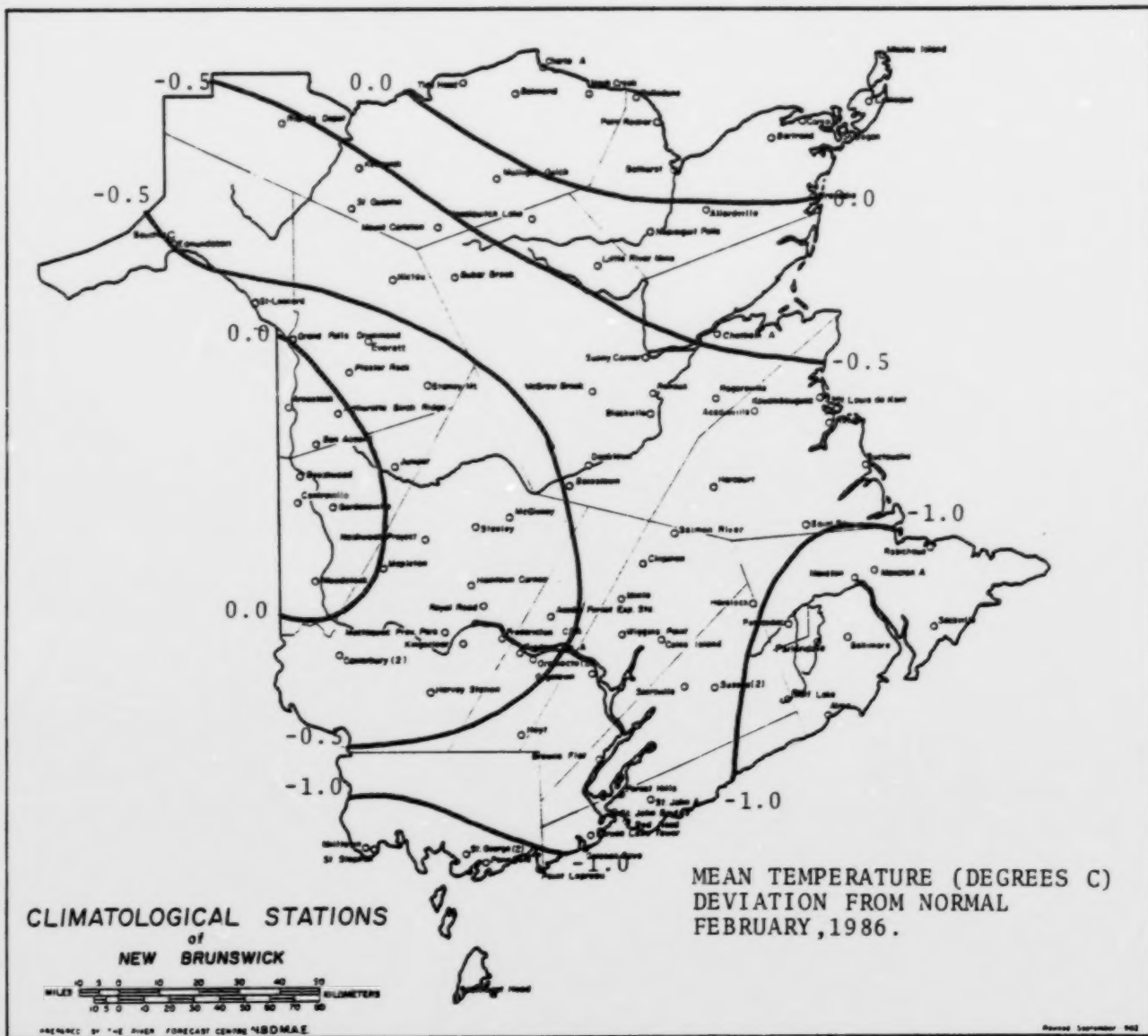
FREDERICTON				BEECHWOOD			HOULTON		
DAY	TEMP. (°C)		PRECIP. (mm)	TEMP. (°C)		PRECIP. (mm)	TEMP. (°C)		PRECIP. (mm)
	MAX.	MIN.		MAX.	MIN.		MAX.	MIN.	
1	4.00	1.40	0.00	2.00		0.00	3.30	0.00	0.00
2	-1.90	-16.80	0.20	-3.50	-20.00	1.00	-2.80	-12.20	0.00
3	-5.80	-11.80	43.10		-18.50		-12.20	-16.10	21.80
4	-8.20	-12.80	1.60				-11.70	-15.00	0.00
5	-6.90	-19.90	16.20	-10.00		58.00		-27.20	21.10
6	-4.00	-14.00	0.20	-6.50	-16.00	0.00	-6.10	-14.40	T
7	-13.10	-17.50	0.00	-12.00	-20.00	0.00	-15.60	-25.00	0.00
8	-9.70	-21.60	0.40	-10.00	-23.00	0.00	-10.60	-20.00	0.00
9	-2.60	-18.20	0.20	-3.00	-21.00	0.00	-4.40	-21.10	0.00
10	1.80	-4.90	0.00		-11.00		0.00	-6.10	T
11	-3.20	-11.00	0.00				-7.80	-17.80	0.00
12	6.10	-18.90	0.00	5.00		0.00		-19.40	0.00
13	5.50	-3.60	1.10	1.00	-10.00	0.00	1.70	-5.60	0.00
14	-9.20	-15.30	0.00	-18.00	-20.00	0.00	-17.20	-20.60	0.00
15	-17.60	-27.10	0.00	-18.50	-36.00	0.00	-20.60	-28.90	0.00
16	-8.70	-20.30	0.00	-8.50	-28.00	0.00	-7.80	-20.60	0.00
17	5.00	-20.90	0.30		-27.50			-23.30	0.00
18	7.70	2.00	0.00					-2.80	0.00
19	4.80	-4.00	15.60	3.00		8.00	5.60	-4.40	12.20
20	8.40	2.40	11.20	5.50	0.00	15.00		2.80	1.30
21	1.20	0.00	1.60	0.00	-1.00	0.00	1.10	0.60	T
22	3.70	-10.90	6.20	-3.00	-13.00	T		-6.70	
23	3.50	-1.70	0.00	-9.00	-9.00	0.00	0.60	-8.90	0.00
24	-14.60	-20.40	0.00		-23.00		-16.10	-25.00	0.00
25	-10.80	-24.90	0.30				-1.10	-23.90	1.80
26	9.10	-14.60	0.60	10.00		14.20		-9.40	10.70
27	14.00	6.10	22.80	12.00	5.00	20.80		6.70	
28	9.60	2.20	1.80	4.00	1.00	6.20	0.00		1.80
29	-7.00	-16.00	0.00		-20.50		-10.00	-20.00	0.00
30	-7.20	-14.60	0.00	-9.00		0.00		-20.00	T
31	-5.90	-16.00	0.00		-18.00		-9.40	-19.40	0.00

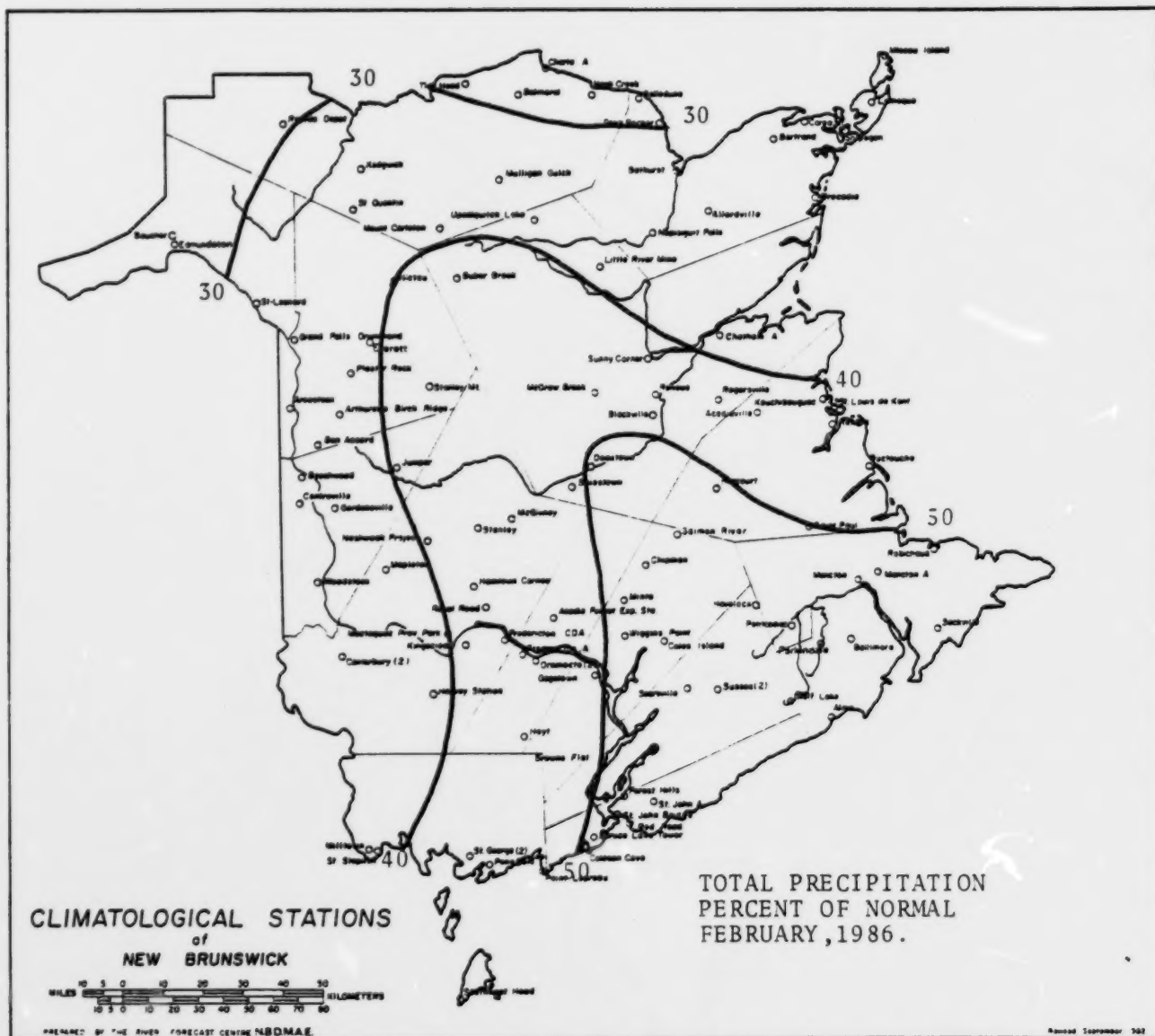




METEOROLOGICAL DATA
FEBRUARY 1986

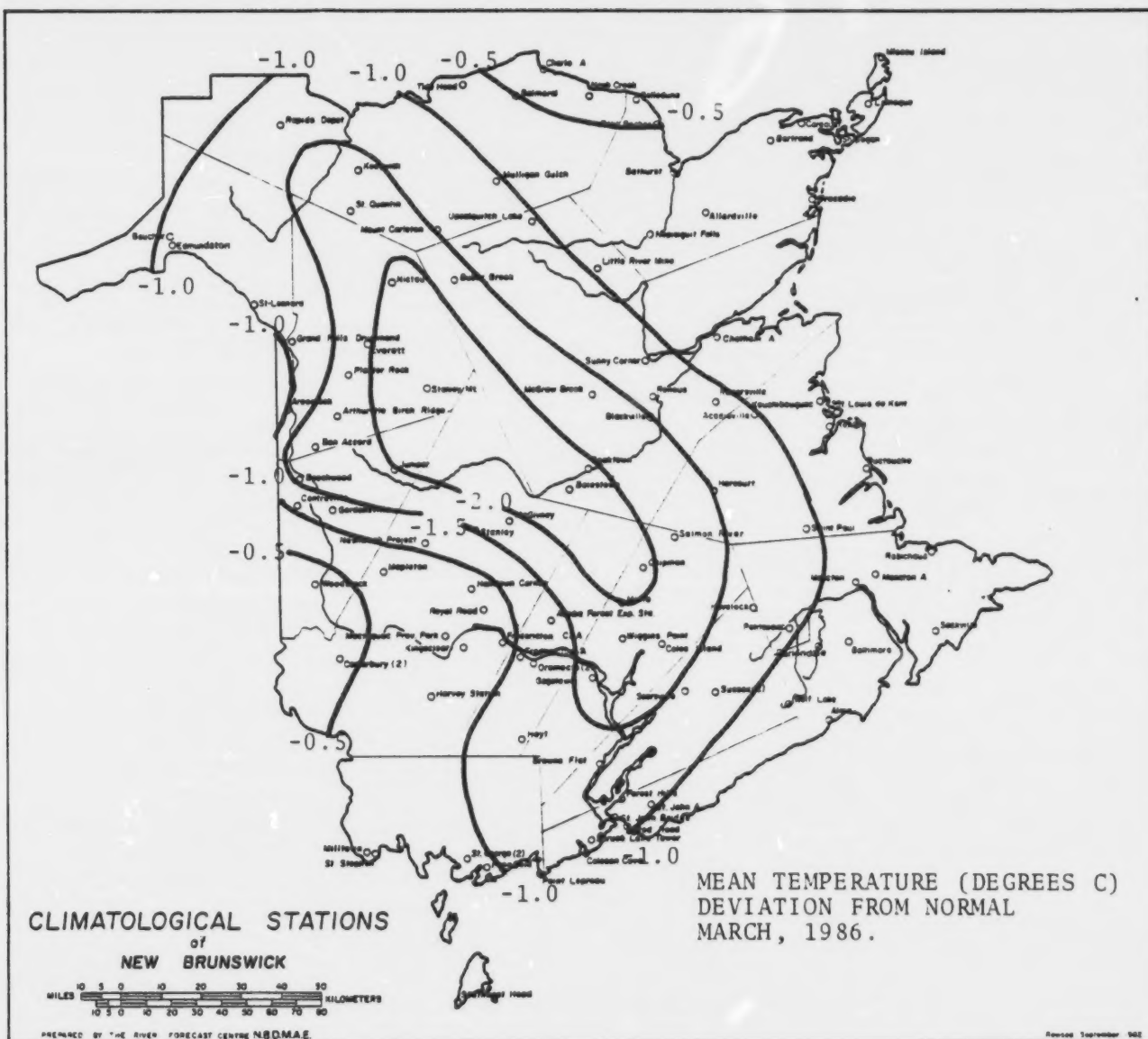
DAY	FREDERICTON			BEECHWOOD			HOULTON		
	TEMP. (°C)		PRECIP. (mm)	TEMP. (°C)		PRECIP. (mm)	TEMP. (°C)		PRECIP. (mm)
	MAX.	MIN.		MAX.	MIN.		MAX.	MIN.	
1	-9.60	-19.30	1.40				-10.00	-21.70	1.30
2	-4.20	-14.90	8.60	-4.00		7.60	-3.90	-13.30	3.80
3	-5.40	-9.50	0.00	-8.00	-11.00	0.00	-6.70	-11.10	0.00
4	-9.60	-20.60	2.40	-9.00	-23.00	2.00	-11.70	-24.40	1.80
5	-2.00	-18.60	3.60	-1.50	-23.00	6.00	-3.90	-16.10	0.80
6	-4.50	-14.30	0.00	-8.00	-17.00	0.00	-10.60	-16.70	0.00
7	-8.00	-20.80	0.00		-19.00		-7.80	-18.30	0.00
8	-3.90	-18.80	0.00				-4.40	-21.70	0.00
9	-2.50	-12.00	0.00	-3.00		0.00	-2.80	-12.80	0.00
10	-1.00	-9.60	0.00	-2.00	-16.00	0.00	-1.10	-17.20	0.00
11	-2.10	-13.90	0.00	-3.00	-17.50	0.00	-2.20	-18.30	0.00
12	-5.60	-19.40	0.00	-5.00	-18.00	0.00	-5.00	-15.60	0.00
13	-5.60	-14.20	0.00	-7.00	-15.50	0.00	-3.30	-12.80	T
14	-2.10	-22.00	1.40		-22.00		-2.80	-14.40	0.00
15	-1.10	-8.80	0.00				-4.40	-16.10	0.00
16	-3.50	-10.70	0.00	-4.00		0.00	-5.00	-18.30	0.00
17	-3.20	-17.60	T	-5.00	-18.00	1.00	-3.90	-22.80	T
18	-1.80	-9.00	0.00	-2.00	-12.00	0.00	-2.80	-22.80	0.00
19	1.20	-10.00	0.00	2.00	-12.00	0.00	0.60	-10.60	0.00
20	5.00	-14.40	0.00	6.00	-15.00	0.00	5.60	-16.70	0.00
21	3.30	-10.10	7.60		-8.00		1.10	-3.30	2.80
22	1.80	-1.70	0.00				-6.10	-11.10	0.00
23	-5.00	-11.60	0.40	-4.00		10.00	-6.10	-21.10	0.30
24	0.40	-6.80	0.20	0.00	-22.00	0.00	2.20	-8.30	0.00
25	-1.30	-12.20	8.10	-3.00	-17.00	T		-13.90	1.80
26	-4.00	-5.20	2.70	-6.00	-13.00	5.00	-6.70	-8.30	1.30
27	-2.80	-14.70	0.00	-4.00	-13.00	0.00	-4.40	-16.70	0.00
28	-2.30	-16.80	0.00		-20.50			-17.20	0.00

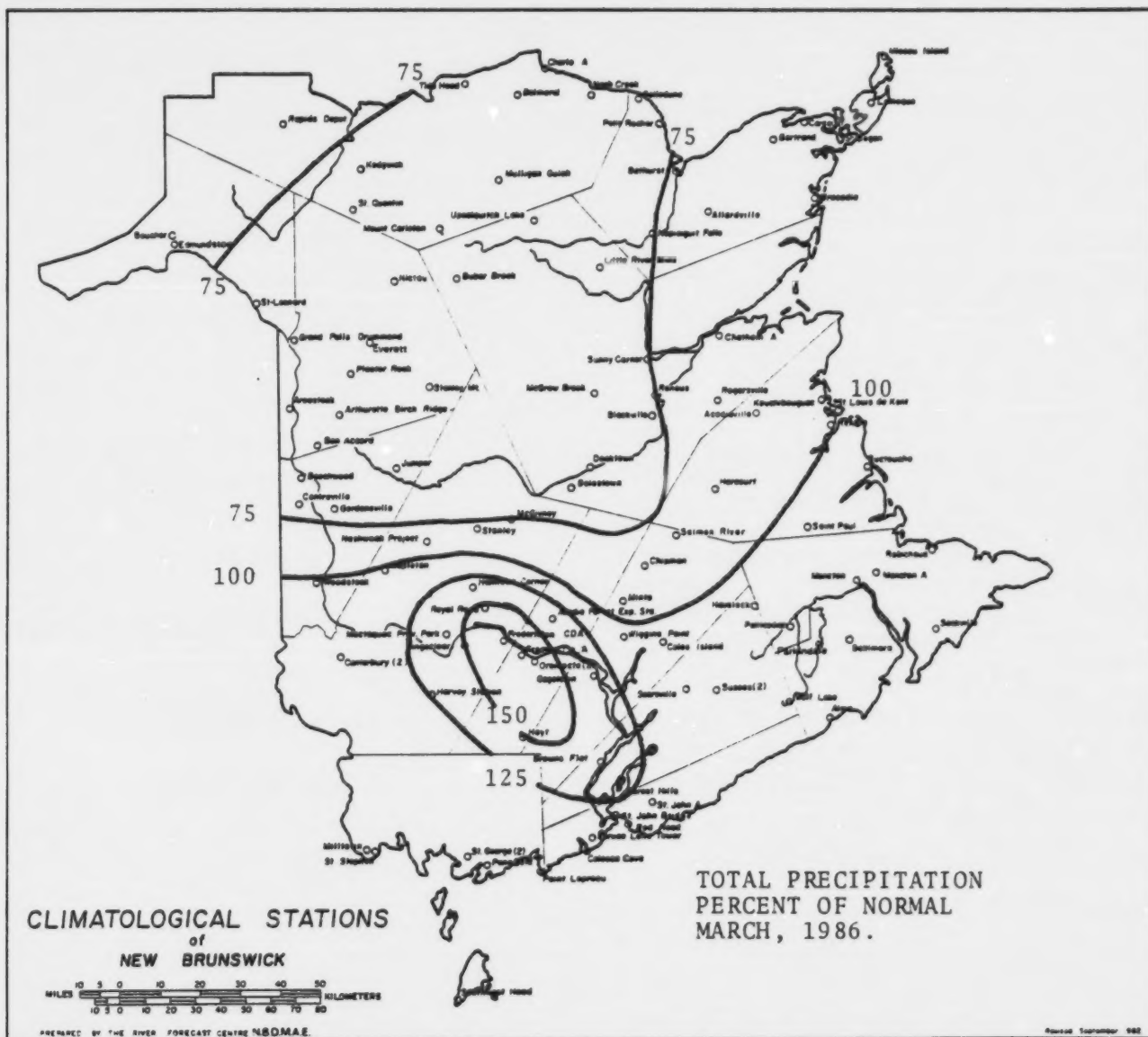




METEOROLOGICAL DATA
MARCH 1986

DAY	FREDERICTON			BEECHWOOD			HOULTON		
	TEMP. (°C)		PRECIP. (mm)	TEMP. (°C)		PRECIP. (mm)	TEMP. (°C)		PRECIP. (mm)
	MAX.	MIN.		MAX.	MIN.		MAX.	MIN.	
1	2.30	-15.20	0.00					-16.70	0.00
2	2.40	-13.50	0.00	1.00		0.00	0.00	-18.90	0.00
3	3.00	-9.90	0.00	3.00	-17.00	0.00	2.20	-17.20	0.00
4	5.10	-12.70	0.00	3.00	-19.00	0.00	3.30	-17.20	0.00
5	6.80	-7.90	0.00	4.00	-18.00	T	3.90	-3.90	0.00
6	-2.40	-9.70	4.20	-4.00	-16.00	T	-7.20	-13.90	3.60
7	-7.30	-9.30	14.60		-16.00		-9.40	-11.10	12.70
8	-8.00	-11.30	0.00					-15.00	0.00
9	-4.90	-20.00	0.00	-5.00		12.00	-5.00	-22.80	0.00
10	-10.60	-18.80	20.90	-7.00	-22.00	8.00		-23.90	6.40
11	-4.10	-11.60	4.00	-1.00	-19.50	0.00	1.70	-12.20	5.10
12	-2.70	-10.60	0.00	-2.50	-13.00	0.00		-11.10	0.00
13	1.40	-21.10	3.80	1.00	-25.00	1.00	0.00	-25.00	3.60
14	0.30	-1.70	18.80		-23.50		-0.60	-2.20	6.60
15	0.00	-1.30	18.80					-2.80	4.60
16	0.30	-1.30	1.00	1.00		0.00	0.60	-3.90	0.80
17	4.00	-4.00	0.00	3.00	-9.00	0.00	4.40	-6.10	0.00
18	7.80	-8.20	0.00	7.00	-9.00	0.00	7.20	-7.20	0.00
19	9.20	-1.20	15.20	8.00	-9.00	12.40	8.90	-2.80	10.90
20	8.40	2.30	0.00	-1.50	-6.00	0.00		-3.30	0.00
21	-5.50	-18.20	0.00		-20.00			-20.00	0.00
22	1.80	-17.20	0.00					-17.80	
23	5.10	-11.00	0.00	7.00		0.00	5.60		0.00
24	4.20	-2.80	0.00	1.00	0.00	0.00	2.80	-1.70	T
25	0.90	-11.50	0.00	1.50	-14.00	2.00		-15.00	0.30
26	18.60	-1.30	0.00	17.00	-11.00	0.00	16.70	-2.20	0.50
27	9.30	5.70	37.60		1.50			3.90	10.70
28	0.90	-3.40	1.80					-2.80	0.30
29	12.00	-3.10	2.80					0.60	0.30
30	16.90	-1.10	0.60				18.90	1.70	1.30
31	12.70	3.30	0.00	12.00		4.00	12.80	2.20	0.00





METEOROLOGICAL DATA
APRIL 1986

FREDERICTON				BEECHWOOD			HOULTON		
DAY	TEMP. (°C)		PRECIP. (mm)	TEMP. (°C)		PRECIP. (mm)	TEMP. (°C)		PRECIP. (mm)
	MAX.	MIN.		MAX.	MIN.		MAX.	MIN.	
1	16.20	-1.60	0.00	18.00	-3.00	0.00	18.30	-2.80	0.00
2	14.00	2.20	0.00	13.50	0.00	0.00	13.90	5.00	0.00
3	9.50	0.70	0.00	8.00	1.00	0.00	9.40	-1.70	0.00
4	12.00	-4.80	0.00	10.00	-5.00	0.00	11.10	-4.40	0.00
5	5.10	-4.70	0.00			0.00	3.90	-7.80	0.00
6	8.30	-8.10	T	10.00	-6.00	6.00	8.90	-10.60	3.00
7	2.00	0.80	15.30	1.00	-0.50	9.00	0.60	-1.10	8.40
8	1.70	-2.10	21.80	1.00	-1.00	9.20	0.60	-1.70	7.40
9	2.20	0.60	18.80	3.00	-1.00	4.20	1.70	0.00	0.30
10	5.20	0.00		2.00	0.00	4.80	3.90	-1.10	0.30
11	7.70	0.00	4.60		-1.00		6.10	1.10	6.10
12	5.20	2.10	6.60				5.00	0.00	4.10
13	11.20	-1.40	0.00	9.00		18.50	11.70	0.00	0.00
14	14.10	-2.60	0.00	10.50	2.00	T	11.70	-0.60	0.00
15	14.30	-1.60	0.00	13.00	-4.50	0.00	12.80	-6.10	0.00
16	15.30	-1.90	0.00	17.00	2.00	0.00	15.60	-4.40	0.00
17	15.20	5.20	0.00	17.00	1.00	0.00	17.20	-2.80	0.00
18	12.00	-1.80	0.00		-2.00		14.40	-2.80	0.00
19	14.30	-3.30	0.00				16.60	-6.70	0.00
20	13.10	-3.00	0.00	18.00		0.00	17.20	-5.60	T
21	13.20	-0.60	1.80	15.00	-2.00	15.40	15.50	4.40	15.00
22	14.30	7.40	3.00	10.00	7.00	7.40	10.00	7.20	6.40
23	6.30	3.00	22.40	10.00	-4.00	2.50	7.80	-1.10	11.70
24	8.30	2.80	2.20	15.00	0.50	7.80	12.20	2.20	1.30
25	12.20	5.00	4.40		6.00		15.60	6.70	1.00
26	13.30	6.20	0.40				15.60	10.60	
27	11.20	5.70	0.20	19.00		1.60	19.40	8.30	0.00
28	19.60	4.80	0.00	22.00	8.00	0.00	22.80	5.60	0.00
29	14.10	8.20	T	20.00	7.00	0.00	19.40	7.80	0.00
30	19.20	1.80	0.00	19.50	4.50	0.00	19.40	3.30	0.00

APPENDIX B

PHOTOGRAPHS



APRIL 2, 1986: SIMONDS LOOKING UPSTREAM



APRIL 2, 1986: SIMONDS LOOKING DOWNSTREAM



APRIL 2, 1986: NEAR SIMONDS GAUGE



APRIL 3, 1986: UPPER SIMONDS



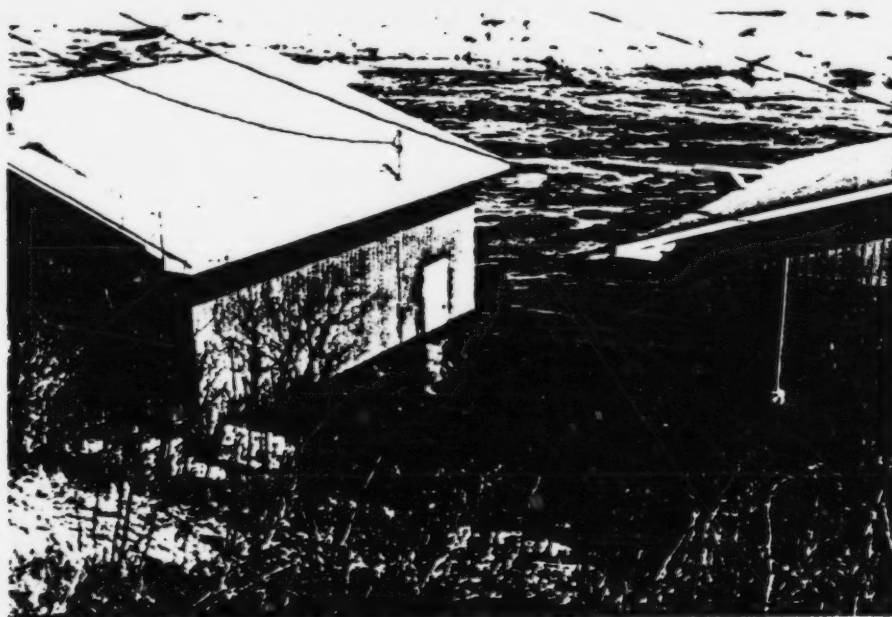
APRIL 3, 1986: UPPER SIMONDS



APRIL 3, 1986: LOWER SIMONDS



APRIL 3, 1986: AIR FIELD - SIMONDS



APRIL 3, 1986: AIR FIELD - SIMONDS



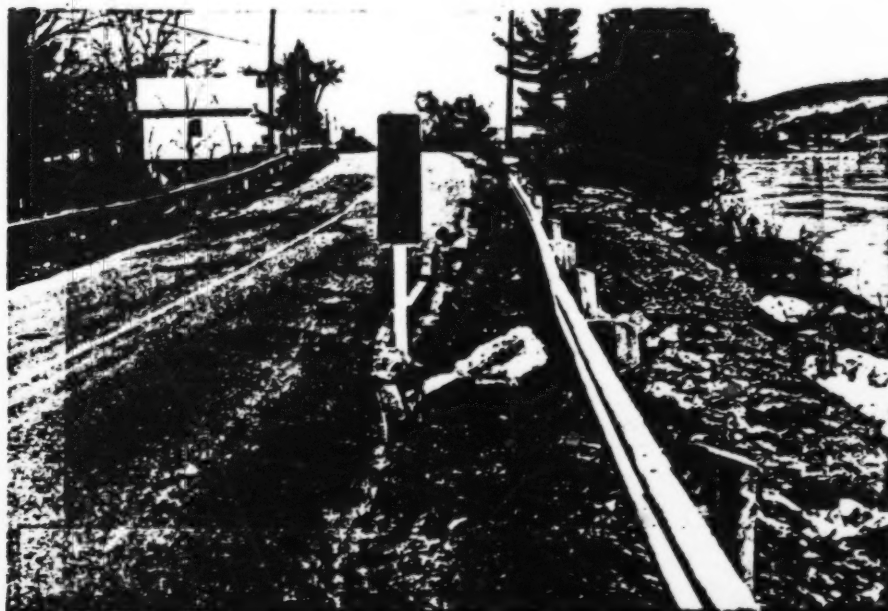
APRIL 4, 1986: UPPER SIMONDS



APRIL 4, 1986: SHAW CREEK



APRIL 4, 1986: UPPER BRIGHTON



APRIL 5, 1986: SIMONDS



APRIL 4, 1986: CONSOLIDATED WINTER JAM - HARTLAND